THE COMMON FROG*

XI.

THE eye of the frog is a beautiful and brilliant object, and relatively large. It is furnished with two eyelids, but, unlike those of man, it is the inferior one which is the more movable. In addition to these it is defended by a third eyelid, called the victitating eyelid, which is similar to that one which may be seen (if watched for) so frequently and rapidly to cross the eye of birds, *e.g.* of a hawk.

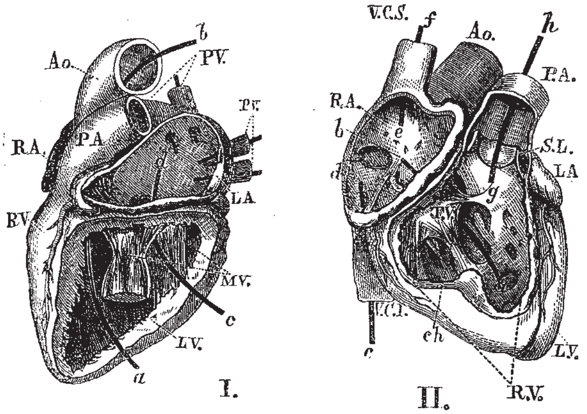

FIG. 74.—I. The left side; and II. the right side of the Heart dissected. I.—*LA*, the left auricle; *PV*, the four pulmonary veins; *cd*, a style passed through the auriculo-ventricular aperture; *MV*, the mitral valve; *ab*, a style passed through the left ventricle into the aorta; *RA*, *RV*, parts of the right side of the heart; *PA*, pulmonary artery.
II.—*RA*, the right auricle; *VCS*, superior vena cava; *VCI*, inferior vena cava, the styles *fe*, *cd*, being passed through them into the auricle; *ab*, style passed through the auriculo-ventricular aperture; *TV*, tricuspid valve; *RV*, right ventricle; *SL*, semi-lunar valves at the base of *PA*, the pulmonary artery, through which the style *gh* is passed; *LA*, *LV*, auricle and ventricle of the left side of the heart.

This structure, however, is no mark of affinity to birds, as it is one which reappears, when wanted, in widely different forms. Thus we find it in the whale, *i.e.* in the highest class of the Vertebrate sub-kingdom, and in certain sharks, *i.e.* in the lowest class of the same.

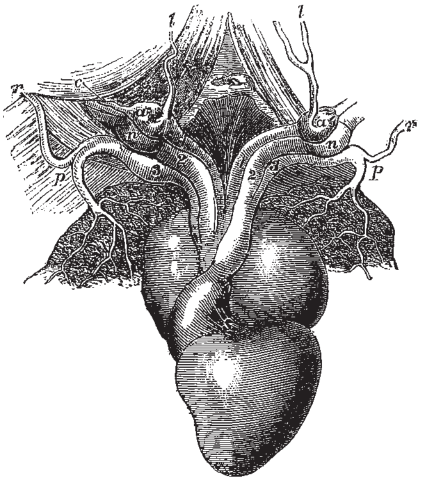

FIG. 75.—The Frog's Heart. The ventricle is below *s*, the aortic bulb is on the left of *s*, and ends in six aortic trunks, three on each side. The first of these (1), ends in the carotid gland (*a*), whence spring the lingual (*l*), and the carotid (*c*), arteries. The second trunk (2), is the root of the great dorsal aorta. The third trunk (3), ends in the pulmo-cutaneous artery (*r*), and the pulmonary artery (*p*), which is shown sending ramifications over each lung.

Eyelids do not exist in all members of the frog's class. Even in its order they are extremely minute, in *Pipa* and *Dactylethra*, which have very small eyes. In *Amphiuma* they are completely wanting, and in *Proteus* and in the *Ophiomorpha* the minute eyeballs are covered with the ordinary and unchanged skin of the head.

The ear of the frog's class presents us with the incipient condition of that part as an organ destined to respond to sonorous vibrations conveyed to it by the atmosphere.

In man the internal ear (enclosed in the densest bone of the skull, named, from its density, "petrous") is a very complex organ. The aperture, surrounded by the folds of the external ear, leads by a canal towards a cavity called the tympanic cavity, which cavity is shut off from the exterior by the tympanic membrane (or drum of the ear), which stretches across the canal at a considerable distance from its external aperture. On the inner side of the tympanic cavity lie the convoluted tubes (richly supplied with nerves) which constitute the real organ of hearing or internal ear.

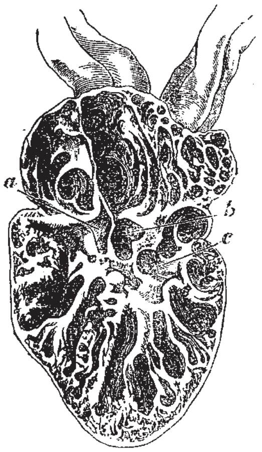

FIG. 76.—Section of heart. *a* and *b*, openings of the auricles into the ventricle; *c*, opening of the aortic bulb into the ventricle.

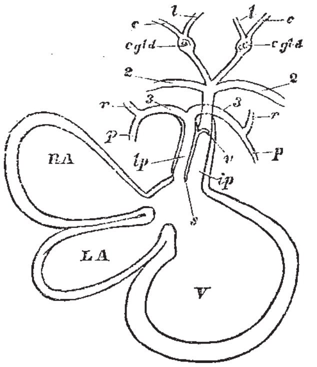

FIG. 77.—Diagram of section of Frog's heart. *LA*, left auricle; *RA*, right auricle; *V*, ventricle; *s*, movable septum dividing the left aortic passage *lp* from the right aortic passage *ip*; *v*, valve; 3, 3, aortic trunks leading to *p*, pulmonary artery and *r*, cutaneous respiratory artery; 2, 2, aortic trunks going to form the great dorsal aorta; *cgld*, carotid gland interrupting the flow of blood into *l*, the lingual artery, and *c*, the carotid artery.

Although the tympanic cavity is shut off from the exterior by the tympanum, it nevertheless is not altogether shut off from the exterior, since it communicates with the back of the mouth by a long and narrow canal termed the Eustachian tube.

It is the existence of these Eustachian openings into the ear from the mouth which causes people when intently listening to keep their mouth slightly open.

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* Continued from p. 307.

In the frog there is no such external canal, but the tympanum is plainly to be seen in the way already described, on the side of the head, covered only by a slightly striated portion of the skin of the body. The Eustachian tube, however, still exists in the frog, though it is short and wide, and the opening of each is to be seen on one side of the back of the mouth.

This condition of things, however, does not exist in all the members of the frog's order, still less of his class. But in *Proteus*, *Siren*, and *Menobranchus* there is no tympanic cavity whatever, and the organ of hearing is simply imbedded in the skull, and probably responds but to sonorous vibrations conveyed to it by the denser aquatic medium, and not at all, or but very imperfectly, to those of the atmosphere.

In the ordinary efts we still meet with an Eustachian canal, but the tympanum is absent.

In the frog's own order, as in *Pelotates* and *Bombinator*, we may fail to find any tympanum, while the Eustachian tubes are all but obliterated, being reduced to the most minute dimensions.

Another condition, however, may be presented which offers a singular contrast, and is the more remarkable from the widely separated geographical situations of the forms which present it. In the South American *Pipa*, as well as in the South African *Dactylethra*, the two Eustachian tubes run together and open at the back of the mouth, by a median and common aperture.

Strange to say, this is the very condition which exists in birds, though most certainly it cannot be taken as any sign of affinity. In the crocodile these tubes have also a common median opening, but, unlike birds, each tube has also its own lateral opening into the throat, so that there come to be three Eustachian openings.

Can the resemblance between *Pipa* and *Dactylethra* in this matter be taken as a serious indication of genetic affinity, in spite of the wide, deep, and probably ancient Atlantic which rolls between the two species now?

This is a question which cannot be confidently answered, seeing in how many other instances structural peculiarities have evidently had an independent origin. Nevertheless, the fact that these two genera agree also in the small size of the eyes, rudimentary eyelids, and vastly expanded sacral transverse process would seem to point to some ancestral and fundamental relationship. If so, however, it is remarkable that no other such forms, or no intermediate ones should have been preserved, seeing that neither kind can be suspected of having migrated to its own habitat from the existing habitat of the other; and therefore that forms similar to that from which we may, if we please, conceive both to have been derived must have had a more or less widely extended geographical distribution and have been numerous in order to have given origin to genera in many respects so different as the two in question.

The Circulation of the Frog

Not only every animal, but every living being, requires, in order to carry on the functions of life, to interchange some of the gaseous elements of its body with gases of the medium (air or water) in which it happens to live.

Another function of extreme generality is that of conveying to all the parts and organs of the body nutritious matter for their growth or for the repair of those destructive effects which the processes of life inevitably produce in them.

In all members of the highest sub-kingdom of animals (*i.e.* in all Vertebrata) these processes of gaseous interchange and nutrition are effected by means of closed vessels, along which the stream of nutritious fluid (the blood) is continually carried in a definite and constant course. During some or other part of that course the blood becomes exposed to conditions specially favourable to the gaseous interchange, the blood parting with carbonic acid gas and obtaining in its place an increased supply of oxygen.

This process of blood oxygenation is termed respiration, and the organs which subserve it are termed respiratory or breathing organs. Such organs in man are the lungs. The central organ of circulation in man is, as all know, the heart, which is a muscular organ, divided into four chambers, or cavities.

These chambers are called "auricles" and "ventricles," and there are two of each—there being an auricle and a ventricle on the right side and also on the left.

Blood that has performed its nutritive functions, and is therefore charged with carbonic acid gas, is called venous blood, and is conveyed by the veins to the right auricle, whence it passes into the right ventricle, which sends it to the lungs for purification.

The oxygenated, or arterial blood, is returned from the lungs to the left auricle, and hence it is directly transmitted to the left ventricle, whence it is driven through the great artery (the *aorta*) into other arteries, and so distributed all over the body. The aorta passes downwards in front of the backbone, when it is called the *descending aorta*. Before turning downwards, however, it gives off great arteries to the arms and head, the *carotid arteries* carrying blood to the latter.

Now it is very important that the blood should not proceed in a direction the reverse of that indicated, and to prevent such misdirection, or regurgitation, special valves are placed at different openings; these valves freely allowing the blood to flow in the proper direction, but instantly opposing an effectual obstacle to a contrary flux.

The openings of the auricles into the ventricles are guarded by valves, as also is the opening of the left ventricle into the aorta, and that of the right ventricle into the artery going to the lungs.

The valve which guards the entrance into the right ventricle is called *tricuspid*, and consists of three flaps attached by delicate tendinous cords in such a way as to hinder the tending backwards of the flaps into the right auricle, and so allowing the blood to flow back into that chamber.

The valve which guards the entrance into the left ventricle is called *mitral* (from a fancied resemblance to a bishop's mitre), and consists of two flaps. The aperture leading from the left ventricle to the aorta is guarded by three crescentric flaps—called the "*semilunar*" valves of the aorta.

In man the whole of the blood is sent to the lungs for purification during each circuit of this most important fluid, and every organ is supplied with oxygenated blood.

If in any animals the process of purification is incomplete it is manifestly desirable that these organs of the body, the functions of which are the most important, should be supplied with that part of the blood which is pure. This consideration eminently applies to the brain, the director and controller of the entire body.

Now all birds and beasts without exception, share with man this perfect aëration of the entire blood, the whole of the blood in the classes *Mammalia* and *Aves* being purified in the lungs before being distributed to the body.

The conditions by which the frog, at the various stages of its existence, oxygenates its blood and directs the purified stream in the most desirable manner, are curious and instructive.

It is generally known that the lower air-breathing Vertebrates (Reptiles and Batrachians) have the heart less completely divided than in the higher classes, so that the oxygenated (or arterial) blood and the unoxygenated (or venous) blood become mixed in the single or imperfectly divided ventricle.

It might well be supposed, and in fact has generally been so, that in animals with a heart so imperfectly divided, the blood sent to the lungs would be necessarily a mixture of venous and arterial fluid, and similarly that the blood distributed by it to all the organs and parts of the body is alike a mixture of pure and impure fluid.

In fact, however, this is by no means the case, and in the frog, in spite of the reception into a single chamber of both venous blood from the body, and of arterial blood from the lungs, special mechanical arrangements effect such a definite distribution of the two sorts of blood, that the unoxygenated fluid from the body is sent to the purifying respiratory surfaces (lungs and skin), and that the pure oxygenated blood alone goes to the head and to the brain.

For the detection of this beautiful mechanism, we are indebted to the careful investigations of Ernst Brücke.*

The heart of the frog consists of a right and left auricle (divided by a delicate septum), both opening into a single ventricle. From the latter proceeds an aortic root (bulbus aortæ) which gives rise to three arterial trunks on each side.

The first of these, or carotid trunk (1), ends in an enlargement (*a*) termed the carotid gland, of spongy structure, which gives rise to two arteries, one the lingual (*l*), the other (*c*), the carotid which goes to the head and brain.

The second, or systemic trunk (2) meets its fellow of the opposite side beneath the spine, and thence passes backwards as the great dorsal (in man descending) aorta, giving off arteries to all parts of the body.

The third, or pulmo-cutaneous trunk (3) ends by dividing into two arteries. The anterior of these (*r*) goes to the skin (which, as we have seen, is in the Frog an important agent in respiration), the posterior one (*p*) goes to the lungs.

The heart itself is of a more or less spongy texture, but the main cavity of the single ventricles open at its extreme right into that of the aortic bulb (*c*). In close proximity to the opening are the openings from the right (*b*) and the left (*a*) auricles respectively.

The aortic bulb is constitutionally divided by a movable septum (Fig. 77, *s*) in such a way, that the passage on the right side of it leads to the carotid and systemic arterial trunks, while the passage on the left side of it leads to the third pair of trunks—namely, those ending in the pulmonary and cutaneous arteries; moreover, there is a valve in the first of these two passages which tends to retard the flow of blood (*v*).

The consequences of these arrangements are as follows:—

When the auricles contract, the venous blood from the right auricle (*RA*) is sent into both right and left passages of the bulb, but by the action of the valve (*v*), and by the structure of the carotid gland, the blood is checked on the right side (*ip*), while on the left it runs freely into the pulmo-cutaneous trunks (*r* and *p*), and thus the respiratory structures receive unmixed venous blood for purification.

As the lungs get gorged with blood, the resistance on the two sides of the septum of the bulb becomes at first equalised and soon becomes the greater on the left side; then the septum is forced over to the left, and the blood, now mixed with pure blood, flowing in from the left auricle, flows freely along the systemic arteries (2 and 2). The obstruction of the carotid glands (*c gld*) being the greatest and the last to be overcome, the carotid and lingual arteries (*c* and *l*) receive the very last of the blood—that, namely, which coming from the left auricle is purely arterial—and in this way oxygenated blood only is supplied to the head, sense organs, and brain.

It should be borne in mind that in order to develop this most beautiful and complex apparatus, the co-ordinate development in due proportion of these beneficial obstructions and checks must have been simultaneously effected in order that their purpose should be duly served. In other words, to account for its formation by an indefinite series of minute happy accidents would seem to require such a successive occurrence of coincidences as to become an improbability so great as to be indistinguishable from impossibility.

ST. GEORGE MIVART

(*To be continued.*)

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* "Beiträge zur vergleichenden Anatomie und Physiologie der Gefäss-Systemes." In the third volume of the "Denkschriften der Mathematisch-Natur-wissenschaftlichen classe der Kaiserlichen Akademie der Wissenschaften." Vienna: 1852.

THE "CHALLENGER" EXPEDITION

BERMUDA

FROM the two visits made by the *Challenger* to Bermuda we learn a good deal about the vegetation of that island. Along the coast, which in some parts is irregular and rocky, and in others of a sandy nature, frequently with heaps of drifted sand, may be seen in abundance a species of *Borrichia*, a low shrub belonging to the compositeæ, *B. arborescens* D.C. being common in the West Indian Islands, and noted for having both glabrous and silvery leaves on the same plant, as well as the two forms on separate plants. In close proximity to the *Borrichia* was seen *Tournefortia gnaphalodes* R.Br., a Boragineous shrub from 2 to 6 feet high, with white flowers and downy leaves, and *Ipomœa pes-capræ* Sw. with its long stem, which frequently creeps to 100 feet or more, and its purple flowers. In the crevices of the rocks grow *Euphorbia glabrata* V., a shrubby glabrous plant common to the West Indies, and on the shores of Florida, Honduras, &c. A species of Tamarix is also abundant, as well as *Conocarpus erectus* L., and *Coccoloba uvifera* Jacq., known in the West Indies as the seaside grape, from the violet-coloured, pulpy acid-flavoured peiranth; an astringent extract like kino is likewise prepared from the bark, and the bark itself is used for tanning leather.

Many trailing plants scramble about on the sand dunes, assisting to bind the loose sand together. Amongst the most important of these is a hard, prickly grass, probably a species of *Cenchrus*, *Cakile æqualis* L'Her, a singular cruciferous plant allied to our Sea Rocket, and a species of *Scævola*. The Mangrove (*Rhizophora mangle* L.) occurs in swamps similar to those which have been so often described by travellers; but beside the true mangrove swamps, there are others occupied by trees of *Avicennia*, *A. nitida* Jacq. being known in the West Indies as the black, or olive mangrove.

In the peat bogs, or marshes, which are surrounded by low ranges of hills, the most striking character of the vegetation is the ferns; species of *Osmunda* are abundant, as well as *Pteris aquilina* L. Some of the marshes, however, have their special character of fern vegetation some species, as for instance *Acrostichum aureum* L. (*Chrysodium vulgare* Fee), being found only in particular spots. The Junipers (*Juniperus bermudiana* Lun.) also thrive in the marshes, but none of the trees at present standing approach in size those that are occasionally found below the surface. These large trunks usually lie at a depth of about two feet. The average diameter of the trunks of existing trees may be taken at from two to three feet, and these are mostly unsound in the centre owing to the marshy ground in which they grow. The largest known living trees in the island measure respectively fifty-nine inches and thirty-nine inches in diameter; the first is hollow, but the second is apparently sound. Amongst other noticeable marsh plants are *Myrica cerifera* L., a shrub the berries of which, in Central America, yield wax from which candles are made, and *Rhus toxicodendron* L., the Poison Oak of North America.

In the fresh-water ponds or lakes inland, some of which are a quarter-mile long, and often are in close contiguity